GL02975-3

GP-106

DRILLING & COMPLETION REPORT

RAFT RIVER
GEOTHERMAL INJECTION NO. 4

(RRGI-4)

August 1977

Susan M. Prestwich
EG&G Idaho, Inc.
Idaho National Engineering Laboratory

ABSTRACT

Raft River Geothermal Injection No. 4 (RRGI-4) is a test injection well designed to inject expended geothermal water into the intermediate resource at the 2000 to 3500 foot depth. The goal of the Raft River Geothermal Project is to determine the feasibility of developing and utilizing medium temperature ($300^{o}F$) geothermal resources for power generation and non-electrical applications.

This well was drilled to test the effects, on the reservoir, of injection at the intermediate level. If the theoretical positive effects are proven, injection at the shallower zone would greatly reduce cost associated with geothermal injection systems.

This report describes the drilling and completion aspects of RRGI-4. Preliminary testing is briefly covered in this report. Future reports will cover the testing results of RRGI-4.

1.0 INTRODUCTION

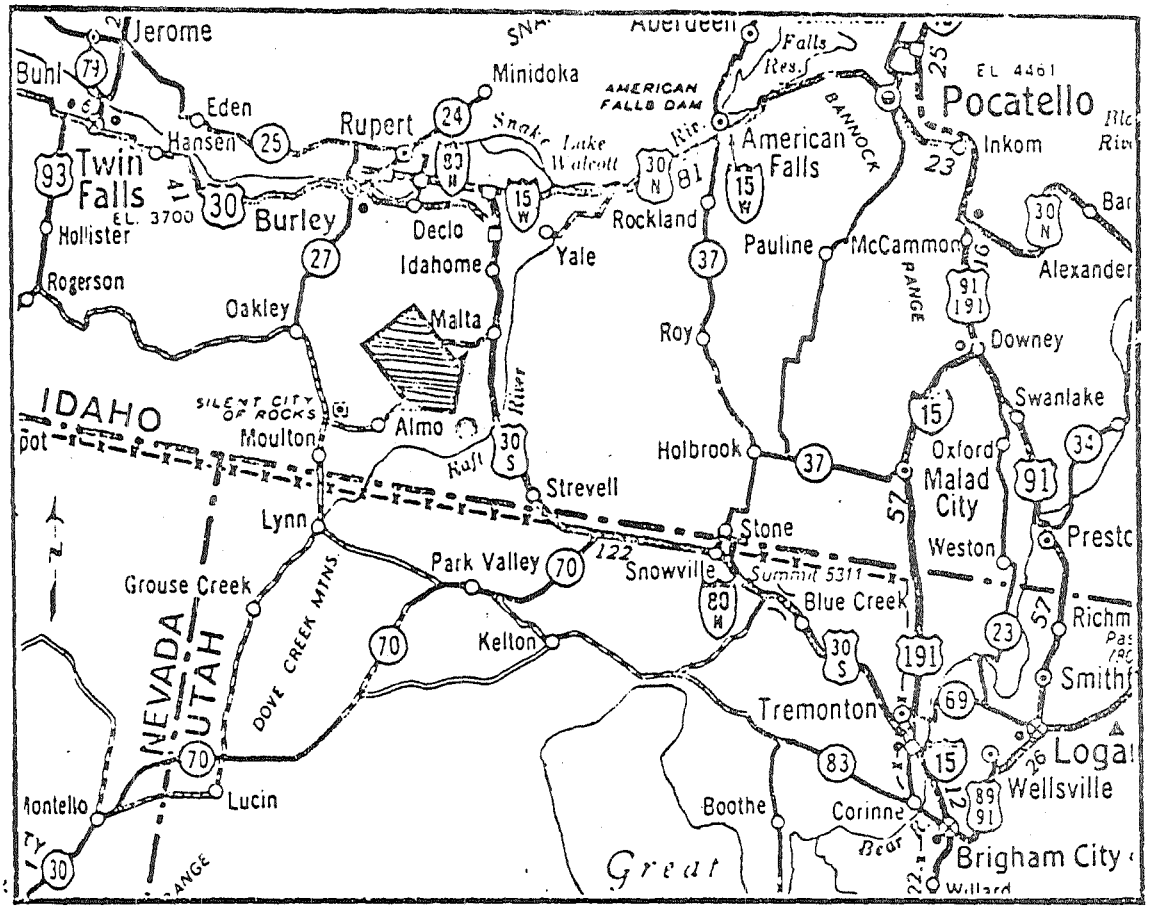
This report describes the drilling and completion of RRGI-4. Previously drilled exploration production wells, RRGE-1, RRGE-2 and RRGE-3 have established the existence of a geothermal reservoir of considerable size. Development stages of the power plant and non-electric experiments has reached a point which necessitates the development of an injection system for geothermal fluid disposal. RRGI-4 was planned as a test injection well to fulfill this need.

The site of RRGI-4 was picked by INEL near the existing RRGE-1 well, to give the most pertinent information of the effects of intermediate injection on the production zone. Drilling began April 8, 1977, and the well was completed on May 4, 1977, at a depth of 2840 feet G.L. (Ground Level).

2.0 INJECTION HOLE DRILLING

2.1 Drilling Summary of RRGI-4

The fourth Raft River geothermal well RRGI-4 was designed for reinjection into the intermediate zone. This zone was selected for reinjection to minimize contamination of the ground water and production aquifers and to reduce well cost. The well location was selected approximately 1/2 mile south of RRGE-1. This area had the attributes of land availability, better understood hydrogeology, and suspect area of major upward leakage from the production zone - affording the ability of monitoring and understanding the interconnections of the leaky reservoirs by producing RRGE-1 and/or RRGI-4. The hope of this injection testing is to create a man-made hydro-cap stopping the upward leakage of the leaky geothermal production zone, thereby retarding the reservoir pressure loss incurred during full scale field production. The cost reduction of well cost and injection pump requirements is significant when compared to deep injection into the production zone.



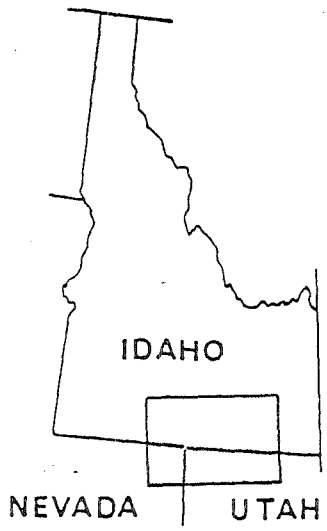


FIGURE 1 IDAHO GEOTHERMAL R&D PROJECT SITE LOCATION

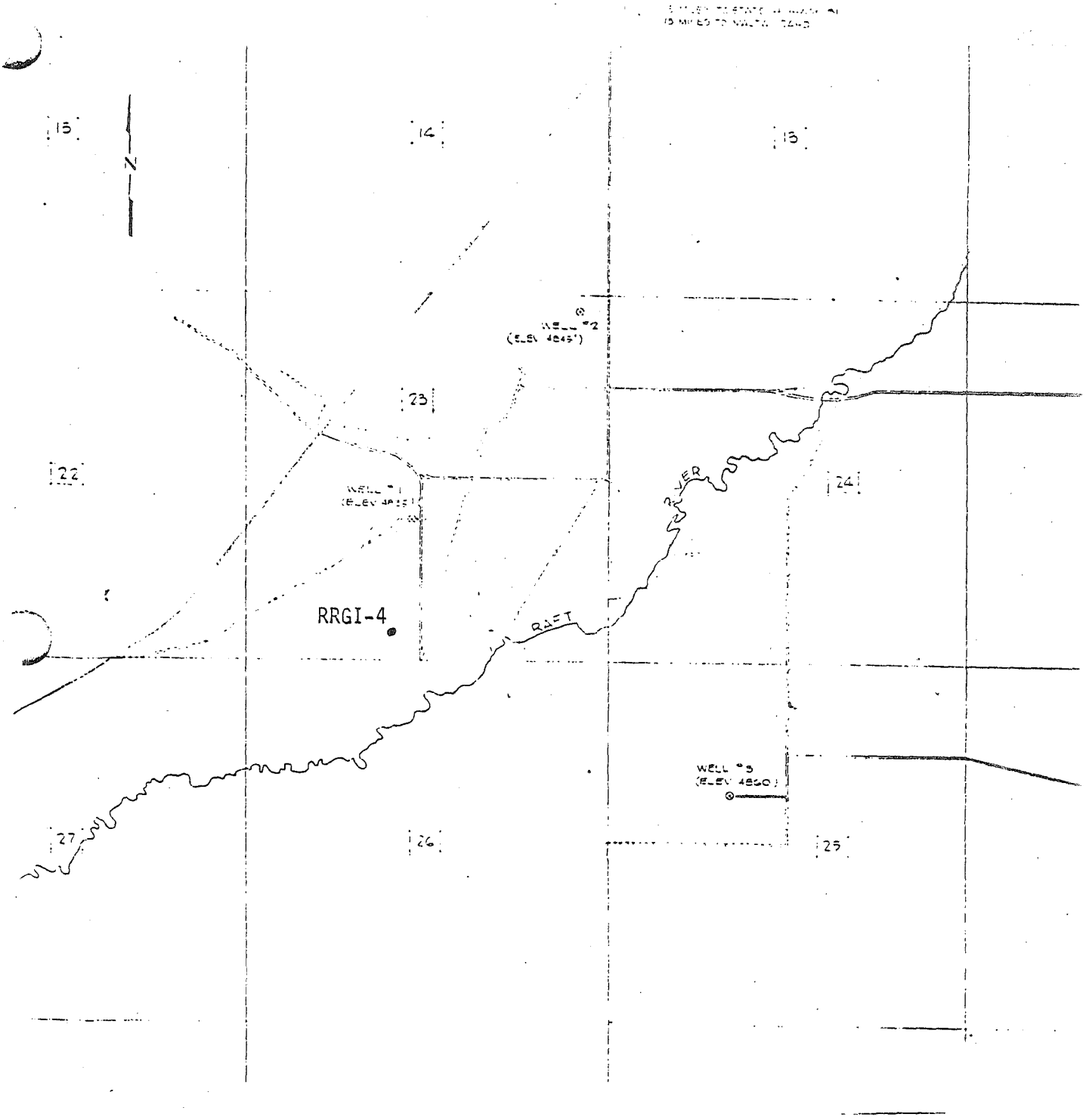
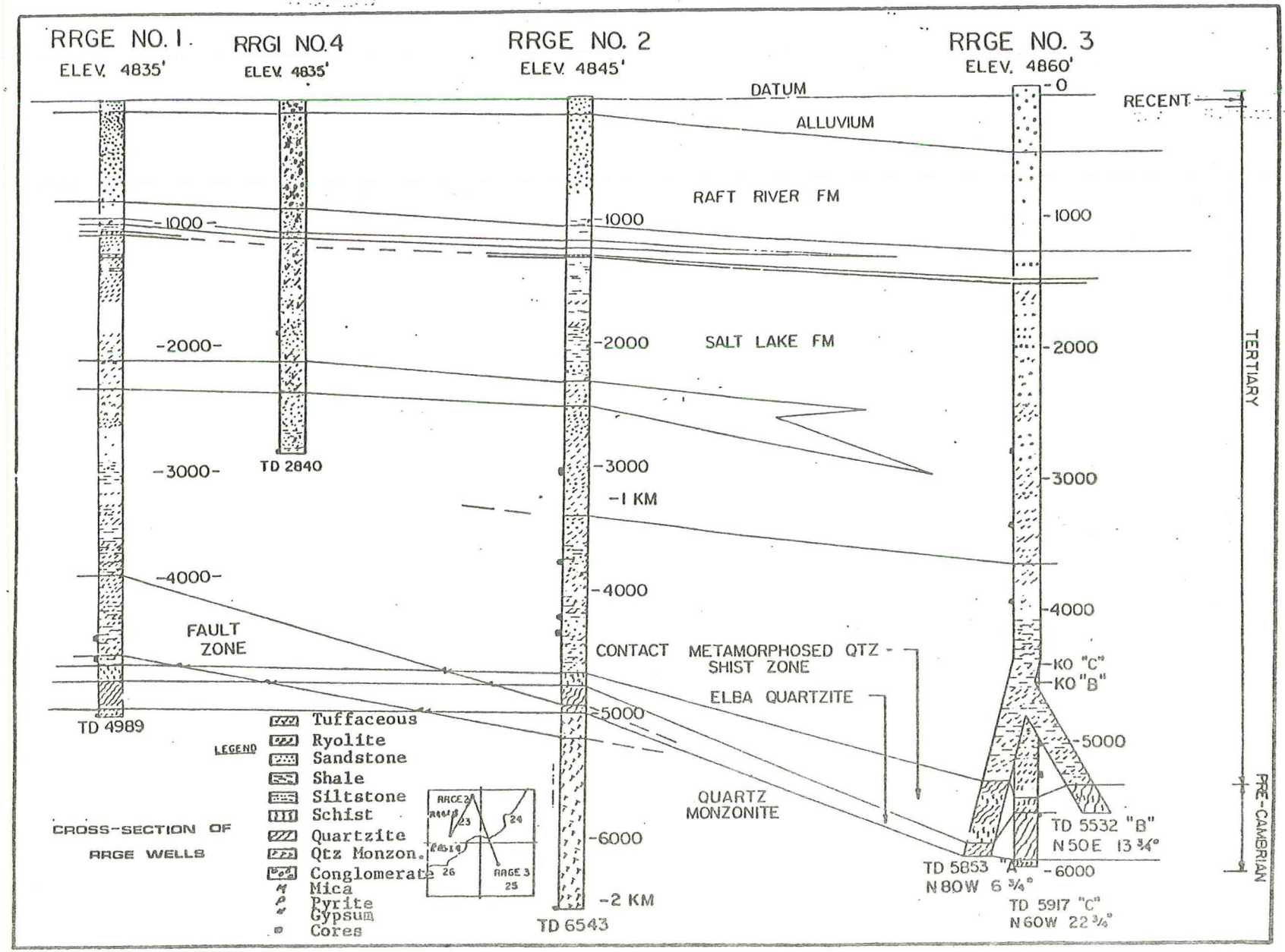


FIGURE 2 RRGI-4 & EXISTING WELL LOCATIONS


RRGE NO. 1
ELEV. 4835'
RRGI NO.4
ELEV. 4835'
RRGE NO. 2
ELEV. 4845'
RRGE NO. 3
ELEV. 4860'
DATUM
0
RECENT
ALLUVIUM
RAFT RIVER FM
1000
2000
SALT LAKE FM
3000
1 KM
4000
FAULT ZONE
CONTACT METAMORPHOSED QTZ - SHIST ZONE
ELBA QUARTZITE
KO "C"
KO "B"
5000
QUARTZ MONZONITE
6000
2 KM
TERTIARY
PRE-CAMBRIAN
TD 2840
TD 4989
TD 6543
TD 5532 "B"
N 50 E 13 3/4°
TD 5853 "A"
N 80 W 6 3/4°
TD 5917 "C"
N 60 W 22 3/4°
LEGEND
Tuffaceous
Ryolite
Sandstone
Shale
Siltstone
Schist
Quartzite
Qtz Monzon.
Conglomerate
Mica
Pyrite
Gypsum
Cores
CROSS-SECTION OF RRGE WELLS
RRGE 2
RRGI 4
RRGE 3
23
24
26
25

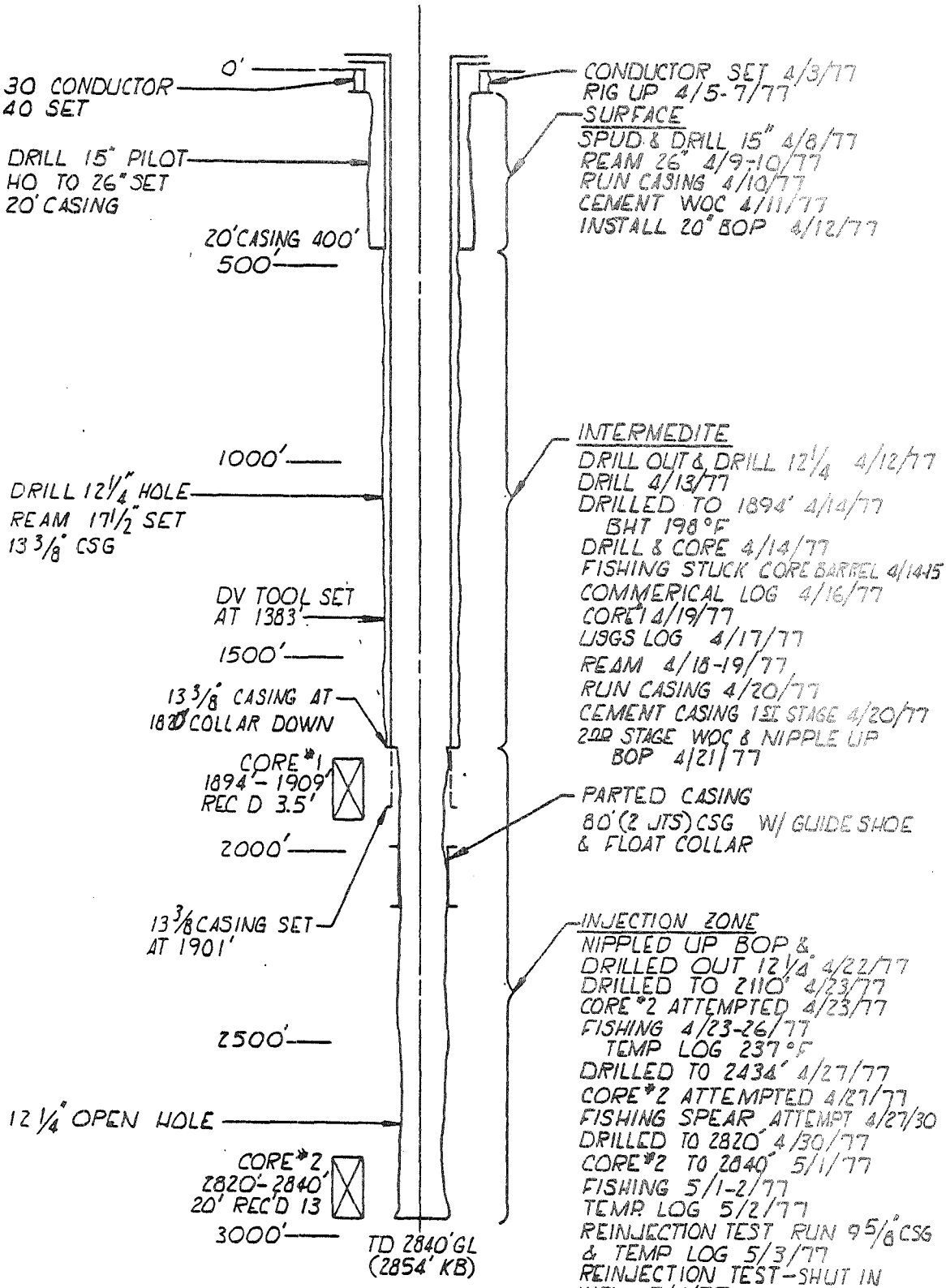
Procurement was completed by the end of March and drilling began April 8, 1977. Colorado Well Service Rig 99, of Rangely Colorado, was awarded the drilling contracts. The rig is a truck-mounted Cabot 900 with 14 foot substructure and hoist capacity of 300,000 pounds.

Surface hole was drilled with a 15 inch bit and reamed to 26 inches. On April 10, 1977, 400 feet of 20 inch K55 94# surface casing was set.

A 12-1/4 inch hole was drilled to 1909 feet and then reamed to 17-1/2 inches, after logging and coring the hole. At a depth of 1894 feet a core was attempted, using the Joides quadracone core bit system on loan from LASL. During trip into the hole with the corebarrel the 12 inch OD corebarrel stabilizer became stuck at 1436 feet (bit depth 1474 feet). Backoff shot service was used to disengage the drill pipe from the coring assembly. The fish was recovered by using jars and bumper sub to free the stabilizer. Dresser Atlas and the USGS ran logs of the hole. Coring was again attempted recovering 3-1/2 feet of core.

At a depth of 1901 feet, 13-3/8 inches K55 54.5# casing was run and stage cemented. The shoe was drilled out with a 12-1/4 inch bit and drilling proceeded to a depth of 2110 feet. At this depth it was necessary to trip out for a new bit. The decision had been made prior to drilling to core at selected intervals which coincided with trips for new bit. During the trip in with the corebarrel an obstruction was encountered at 1887 feet (1901 feet KB). Milling tools were used accomplishing only sidetracking around the fish. Logging determined the fish to be the 13-3/8 inch casing show, float collar (one joint up) and 2 joints casing which parted and fell 67 feet. A fishing spear attempt was made to jar the fish loose and let it fall downhole, hopefully creating a more vertical entry through the casing. The fish could not be moved. Attempts to pass the bit and string through the parted casing were made and were successful three times, enabling drilling to proceed to a depth of 2820 feet and a second core from 2820 - 40 feet.

RRGI – 4


0'
30 CONDUCTOR
40 SET
DRILL 15" PILOT
HO TO 26" SET
20' CASING
20' CASING 400'
500'
1000'
DRILL 12 1/4" HOLE
REAM 17 1/2" SET
13 3/8" CSG
DV TOOL SET
AT 1383'
1500'
13 3/8" CASING AT
1820' COLLAR DOWN
CORE #1
1894' - 1909'
REC'D 3.5'
2000'
13 3/8 CASING SET
AT 1901'
2500'
12 1/4" OPEN HOLE
CORE #2
2820'-2840'
20' REC'D 13
3000'
TD 2840' GL
(2854' KB)
CONDUCTOR SET 4/3/77
RIG UP 4/5-7/77
SURFACE
SPUD & DRILL 15" 4/8/77
REAM 26" 4/9-10/77
RUN CASING 4/10/77
CEMENT WOC 4/11/77
INSTALL 20" BOP 4/12/77
INTERMEDITE
DRILL OUT & DRILL 12 1/4 4/12/77
DRILL 4/13/77
DRILLED TO 1894' 4/14/77
BHT 198°F
DRILL & CORE 4/14/77
FISHING STUCK CORE BARREL 4/14-15
COMMERICAL LOG 4/16/77
CORE 4/19/77
LOGS LOG 4/17/77
REAM 4/18-19/77
RUN CASING 4/20/77
CEMENT CASING 1ST STAGE 4/20/77
2ND STAGE WOC & NIPPLE UP
BOP 4/21/77
PARTED CASING
80' (2 JTS) CSG W/ GUIDE SHOE
& FLOAT COLLAR
INJECTION ZONE
NIPPLED UP BOP &
DRILLED OUT 12 1/4" 4/22/77
DRILLED TO 2110' 4/23/77
CORE #2 ATTEMPTED 4/23/77
FISHING 4/23-26/77
TEMP LOG 237°F
DRILLED TO 2434' 4/27/77
CORE #2 ATTEMPTED 4/27/77
FISHING SPEAR ATTEMPT 4/27/30
DRILLED TO 2820' 4/30/77
CORE #2 TO 2840' 5/1/77
FISHING 5/1-2/77
TEMP LOG 5/2/77
REINJECTION TEST RUN 9 5/8" CSG
& TEMP LOG 5/3/77
REINJECTION TEST-SHUT IN
WELL 5/4/77

Predrilling parameters which were set included a maximum total depth of 3500 feet and not to drill to a depth which would exceed a bottom hole temperature of 250°F.

Temperature logs taken during this period show temperatures of 237°F at the top of the parted casing (hole depth 2434 feet) and 252° at 2700 feet at total depth of 2840 feet. Artesian flow had reached 250 - 300 gpm. The decision was made to terminate drilling. Prior to releasing the rig, four joints of 9-5/8 inch casing were passed through the parted 13-3/8 inch casing to verify that the well could be deepened and completed as a production well at a later date.

Short reinjection tests were run to verify predictive reinjection capacities of the well. Long-term tests are planned prior to full-scale reinjection. (See Figure 3 for drilling summary.)

2.2 Containment Equipment

2.2.1 Surface Hole

A 20 inch single gate Shaffer blow out preventer was set between the 20 inch x 12 inch expansion spool and drilling nipple for drilling the 17-1/2 inch hole to 1909 feet.

2.2.2 Open Hole

After setting the 13-3/8 inch casing at 1901 feet the following containment stack was used listed in order of position from expansion spool up.

1. WKM 20 inch x 12 inch expansion spool
2. WKM 12" master valve
3. Adaptor spool
4. Shaffer double gate BOP, 12 inches
5. Hydril Type GK BOP, 12 inches
6. Grant rotating head, 12 inches

See Figure 4.

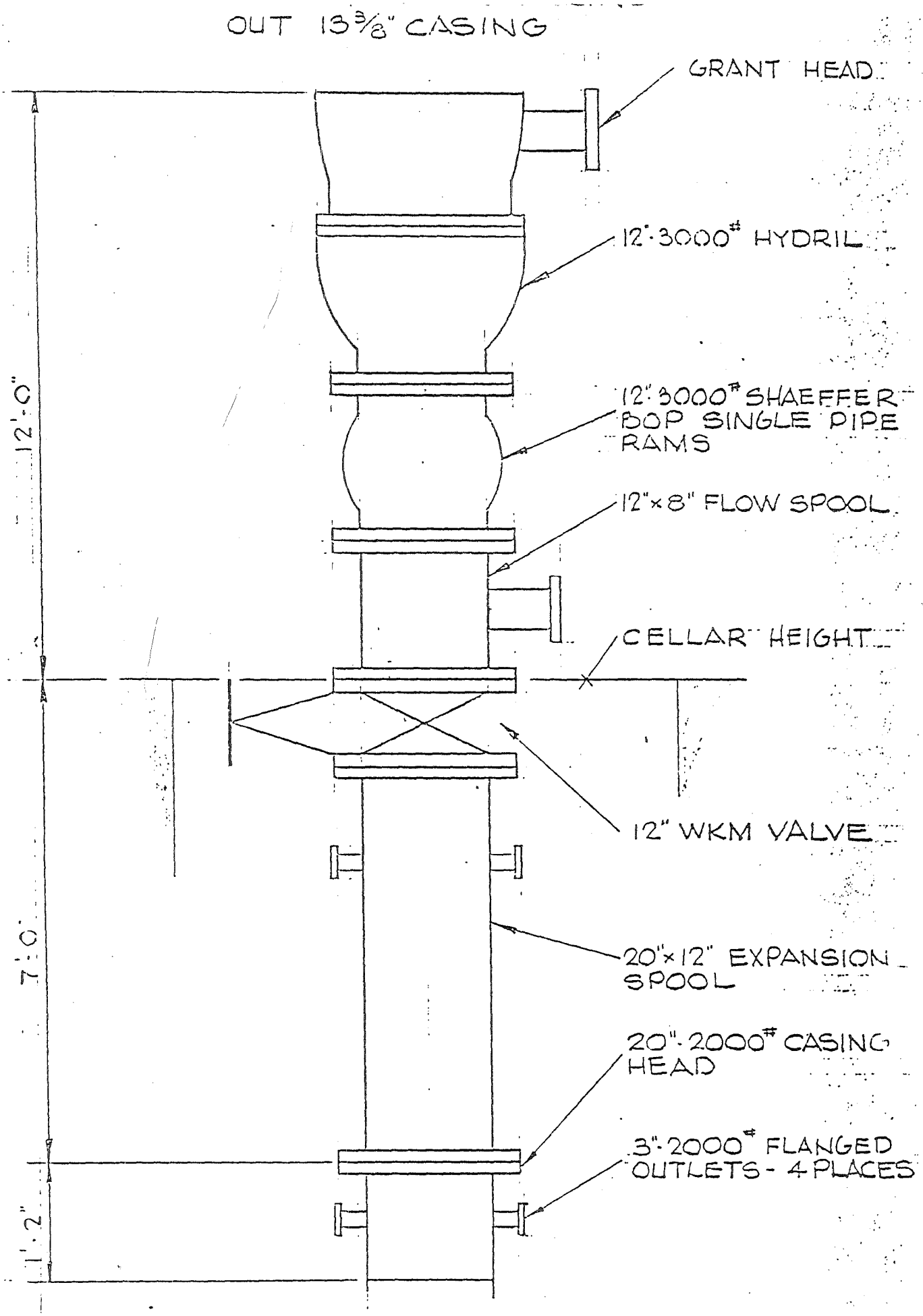

OUT 13 3/8" CASING
GRANT HEAD
12"-3000# HYDRIL
12"-3000# SHAEFFER BOP SINGLE PIPE RAMS
12"×8" FLOW SPOOL
CELLAR HEIGHT
12" WKM VALVE
20"×12" EXPANSION SPOOL
20"-2000# CASING HEAD
3"-2000# FLANGED OUTLETS - 4 PLACES
12'-0"
7'-0"
1'-2"

FIGURE 4

2.2.3 Cellar

An 8 ft x 10 ft x 8 ft reinforced concrete cellar was built to accommodate the BOP stack.

2.2.4 Drilling Recorder

A geolograph drilling recorder was used during drilling to record depth, penetration rate, bit weight and pump pressure.

2.3 Downhole Equipment & Services

2.3.1 Surface Casing

Ten joints 20 inch H40 casing was tack welded at each joint and set and cemented at 400 feet. Parrish Oil tool casing crew ran the casing.

2.3.2 Intermediate Casing

Forty-nine joints of 13-3/8 inch 54.5 lb. K55 range 3 casing, guide shoe, float collar and DV tool were run by Lamb "JAM" (Joint Analyzed Make-Up) system. The second joint up from the guide shoe did not make up well. It showed torquing of 13,600 ft/lbs. The average joint torque was 6800 ft/lbs. The 13,600 ft/lb torque could have resulted from the threaded ends butting against each other.

2.3.3 Bit Summary

A 15 inch hole was drilled to 407 feet with a Security S3J bit then reamed to 26 inches with a Smith hole opener.

A 12-1/4 inch hole was drilled from 400 feet to 1901 feet with Smith non-sealed bearing bits. Then reamed with a 17-1/2 inch hole opener.

A 12-1/4 inch hole was drilled to 2840 feet with water and completed open hole.

2.3.4 Coring

Two cores were recovered using a Joides 8 inch O.D. x 30 feet long corebarrel. The Joides system components were loaned to INEL by Los Alamos Scientific Lab and Scripp Oceanographic Lab. The system is comprised of an 8 inch marine corebarrel and a 9-7/8 inch Smith Tungsten carbide 4-cone bit. The core has a 2-1/4 inch O.D. This system was developed by Scripp for coring the ocean bottoms. It was used with high recovery on the LASL Hot Dry Rock project coring granitic rock. It had not previously been tried in the sedimentary type rock which occur at Raft River. Recovery percentage was better in the deeper more endurated sediment.

The first core attempt occurred at a depth of 1894 feet. The 12-1/4 inch corebarrel stabilizer stuck at 1450 feet. Apparently, either a dogleg or out or gage hole caused the problem. On re-entry with an 11 inch stabilizer a core was successfully taken. Coring depth was from 1894 feet to 1901 feet; recovering 3.5 feet micaeous sandstone.

A third core attempt occurred at 2110 feet after drilling out the shoe. An obstruction occurred at 1887 feet on the trip in the hole with the corebarrel. The obstruction was later determined to be parted casing.

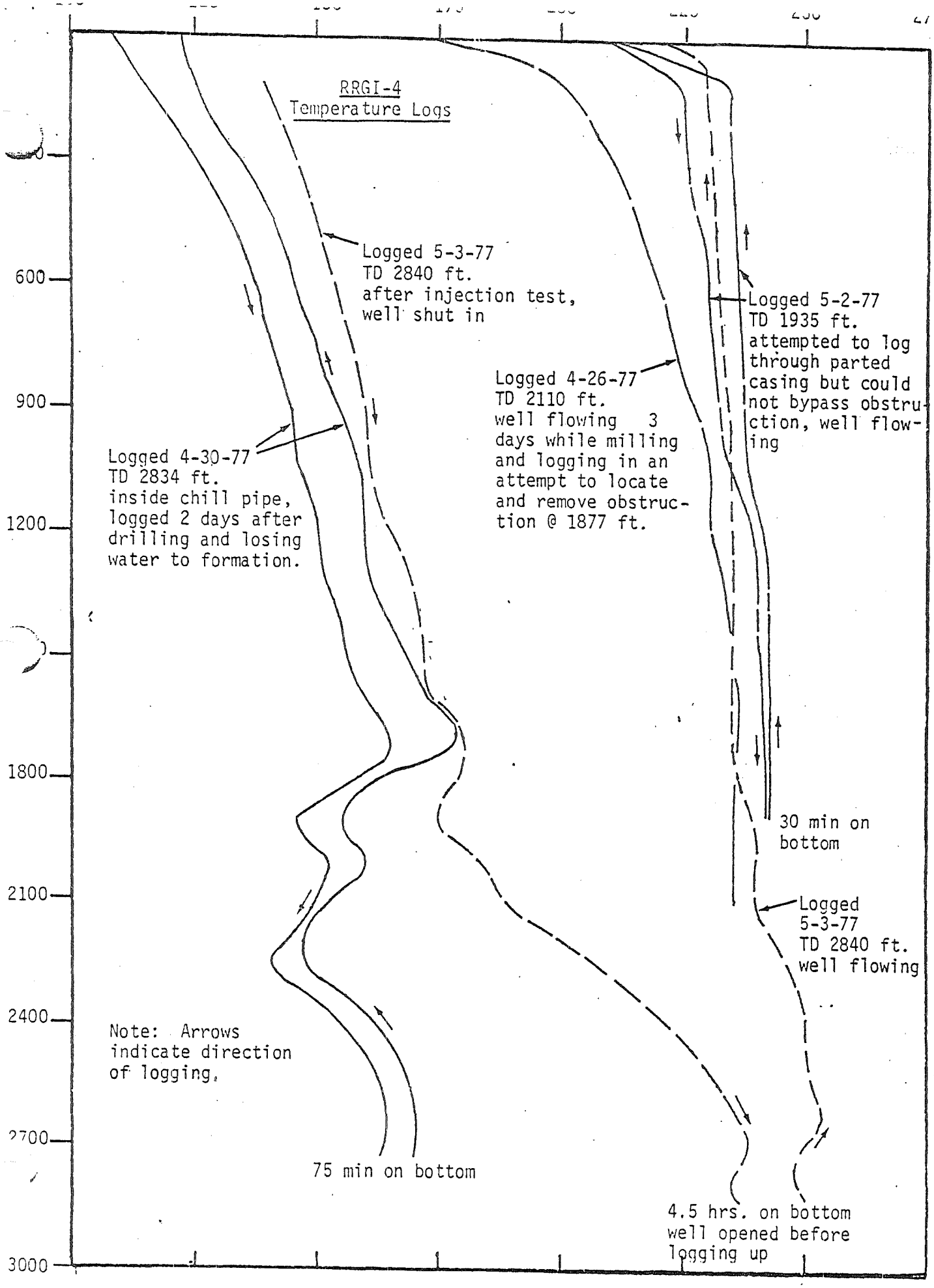
Coring was not attempted again until a depth of 2820 feet. Twenty feet were cored recovering 13 feet of fractured micaeous sandstone and siltstone.

2.3.5 Drilling fluid

A 8-9 lb. gel mud, viscosity 41 was used to drill surface hole. Gel mud was used to drill the 17-1/2 inch hole to 1901 feet. Mud weight was held at 9.5 with viscosity 36-52.

Drilling below 1909 feet was performed with water from RRGE-1 domestic well and reserve pit.

All circulation was lost at 2431 feet.


RRGI-4
Temperature Logs
600
900
1200
1800
2100
2400
2700
3000
Logged 5-3-77
TD 2840 ft.
after injection test,
well shut in
Logged 4-30-77
TD 2834 ft.
inside chill pipe,
logged 2 days after
drilling and losing
water to formation.
Logged 4-26-77
TD 2110 ft.
well flowing 3
days while milling
and logging in an
attempt to locate
and remove obstruc-
tion @ 1877 ft.
Logged 5-2-77
TD 1935 ft.
attempted to log
through parted
casing but could
not bypass obstru-
ction, well flow-
ing
30 min on
bottom
Logged
5-3-77
TD 2840 ft.
well flowing
Note: Arrows
indicate direction
of logging.
75 min on bottom
4.5 hrs. on bottom
well opened before
logging up

2.3.6 Sample Logging

Samples were taken at 20 foot intervals. Samples indicate good porosity and high permeability throughout the section. Mostly semiconsolidated tuffaceous and non-tuffaceous sandstones and siltstones comprise the section. An abundance of biotite mica occurred throughout. Cementing material was calcareous. A few zones show hydrothermal alteration of biotite to chlorite.

2.3.7 Formation Tops

The only formation penetrated was the Tertiary Salt Lake Formation.

2.3.8 Logging

Commercial logs were taken at 1884 feet. The logs run were Gamma density, neutron density, sonic and dual induction.

No commercial logs were run at well completion. It is impossible at the present time to log the well through the parted casing.

Temperature logs were run during the drilling of the 12-1/4 inch open hole. The parted casing made logging beyond the top of the casing impossible. Two temperature logs were taken inside the drill pipe at total depth. See figure (of temperature log). Dialog shot service was used to back off the drill pipe from the stuck corebarrel during the fishing operation. Petrolog services were used to determine the obstruction (parted casing) at 1887 feet. The diagnostic logs run were caliper, cement bond and collar locator. The caliper was the most informative in pinpointing the problem.

2.3.9 Cementing

Surface Casing - The 20 inch casing was cemented in one stage with the guide shoe at 400 feet GL. with 630 sacks 50-50 Pozmix, 35% silica flour, and 2% calcium chloride. Slurry weight was

15.1 lbs. per gallon and yield us 1.44 cubic feet per sack. Sixty barrels of water were pumped ahead of the slurry displaced by gel. Started pumping at 4:05 A.M. with CIP at 5:20 A.M. Good circulation was maintained throughout the operation and cement returns were obtained at the surface.

Intermediate Casing - The 13-3/8 inch casing was cemented in 2 stages. The shoe was set a 1901 ft GL. A DV tool was placed at 1397 feet. The first stage was cemented with 368 sacks of 50-50 Pozmix with 35% silica flour and .03% Hallad 9 (wt. 15.1 #/gal.) with 60 bbl water ahead. Pumping pressure was 300-500 psi with increase to 1250 psi when plug was set. Pumping started at 8:42 P.M. with CIP at 10:10 P.M. WOC 8 hours between stages. The second stage started at 7:00 A.M. with CIP at 8:15 A.M. Sixty barrels of water ahead of slurry: 1013 sacks 50-50 Pozmix with 35% silica flour displaced by water followed by mud. Pumping pressures 700-750 psi jumping to 1500 psi when plug was bumped. Good circulation and returns throughout.

3.0 DRILLING PROBLEMS

3.1 Stuck Corebarrel

While running with the corebarrel on the first core run the core assembly stabilizer (12-1/4 inch O.D.) immediately above the corebarrel became stuck at 1450 feet. The stabilizer was located 34.56 feet above the bit. Working the drill pipe did not free the stabilizer. Dialog shot service was called out. While waiting on Dialog 1,000 barrels of diesel oil were spotted but the wait time was too short for the diesel to do much good. Dialog set off 2 string shots at 1448 feet. The drill pipe was backed off the core assembly. Re-entered the hole with Bowen 8 inch jars and bumper sub and screwed back into the core assembly. The jars were set off and the freed core assembly was retrieved. An 11 inch O.D. stabilizer replaced the 12-1/4 inch stabilizer for future coring. This problem cost 1-1/2 rig time.

3.2 Parted Casing

A 28 hour WOC followed the cementing of the 13-3/8 inch casing before drilling out the cement. Drilling took 4-1/2 hours with

casing pressure tests of 300 psi. The hole was deepened to 2110 feet at which point the bit was worn. During the following trip into the hole an obstruction was encountered at 1887 feet. The obstruction was considered a loosened casing shoe or possibly collapsed casing. Attempts to mill the obstruction were made, but with little improvement in hole conditions. Petrolog was called out to run diagnostic logs; Caliper, collar locator, and cement bond log. The caliper definitely determined the casing shoe and two joints casing had parted and fallen downhole 67 feet (top of parted casing now at 1887 feet). The collar locator log determined that there is a collar at the bottom of the cemented casing looking down toward the parted section. The cement bond log shows good bond to approximately 1750 feet and about 70% bonding below 1750 feet.

It appears that at least three events happened causing the casing to part. The events happening singley would in all probability not have caused problems but in combination caused the casing to part. The formations of the upper zones are semi-consolidated and do not place the casing shoe in endurated beds. The cement was over-retarded. The drill cuttings show the cement still soft days later. Also, the poor bond shown by the cement bond log indicates the cement bond was broken due to soft annular cement during the drilling of the cement inside the casing. The high makeup torque on the joint that parted could have cracked the collar and/or sheared the lower casing threads. Or the soft cement would not hold the casing and the rotating action of the bit inside the casing unthreaded (backed off) the casing. In either case, the soft cement could not hold the casing and allowed the casing the drop.

Attempts to mill the casing caused sidetracking around the parted casing on the low side. Simultaneously hole enlargement was created by washout due to the drilling fluid action. The large hole diameter at the top of the parted casing makes entry into the casing difficult.

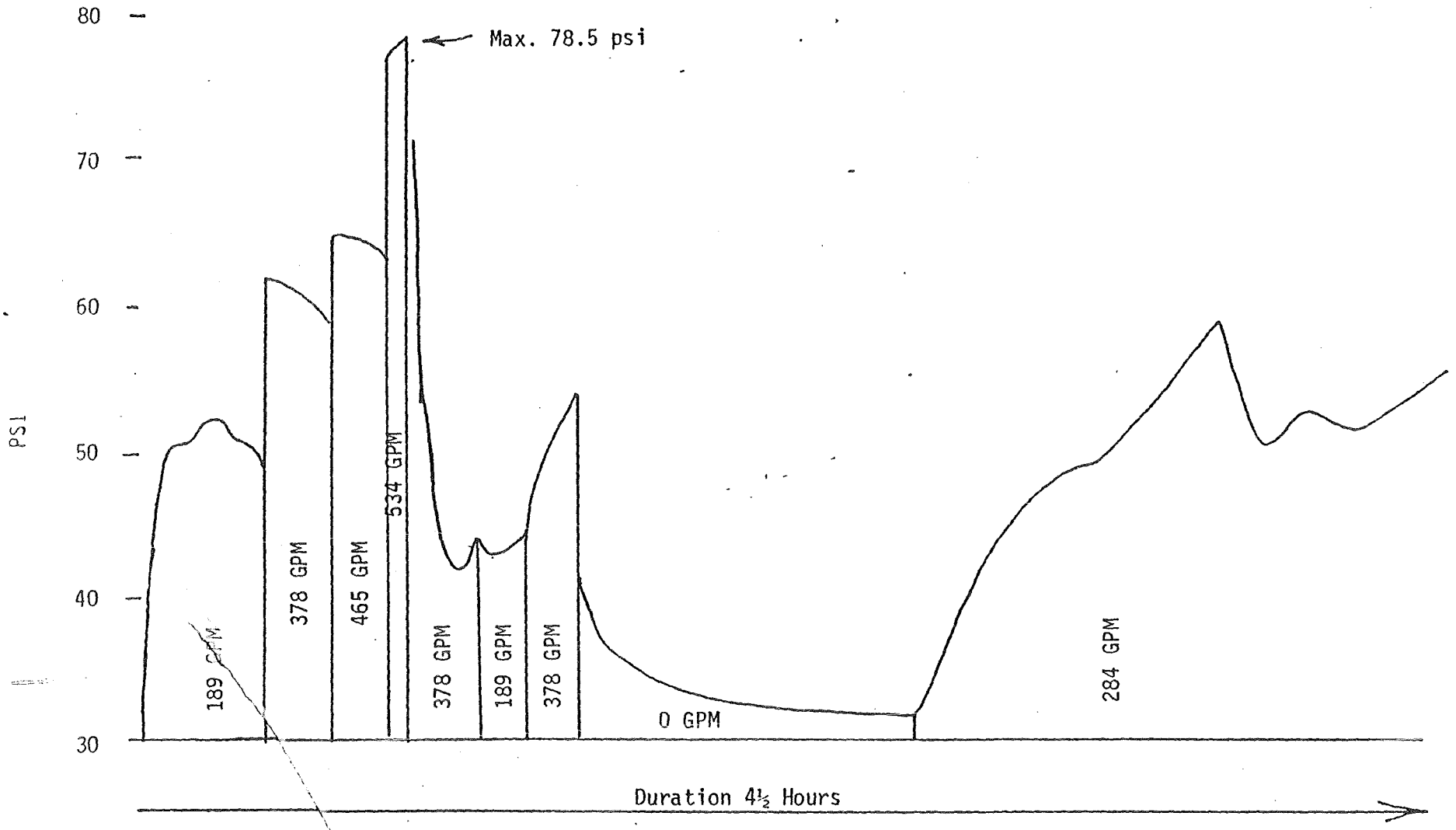
Prior to well completion four joints of 9-5/8 inch casing with a modified guide shoe was run into the hole. The casing was successfully passed through the parted 13-3/8 inch casing. This verified the well could be deepened and completed at a later date utilizing a 9-5/8 inch liner.

The time lost by this problem was approximately 10 days.

4.0 INJECTION TEST

At a depth of 2840 feet, a preliminary injection test was ran for 5 hours, utilizing the two rig pump. Pump #1 - 6.3 gal/stroke, Pump #2 2.6 gal/stroke (90% efficiency). The intital wellhead pressure was 32 psi. The test was run by periodically stepping up strokes to maximum output of 534 gpm. The maximum pressure recorded was low - 78.5 psi. The strokes were then step reduced to zero. Pressure returned to 32 psi within 1 hour of shut-in. The formations appeared to more readily accept fluid with time. Initial (0052) 189 gpm reached 50 psi but later (0135) only reached 44 psi. Not all of the pressure difference can be attributed to water density differences.

RRGI-4 PUMP INJECTION TEST
May 3, 1977



Completion Report
RRGI-4, 1977, IDO-

Susan

DAILY DRILLING REPORTS

March 31, 1977	Cellar completed
April 3, 1977	Rat, mouse and conductor set
April 4, 1977	Rig on location
April 5-7, 1977	Rigging up Colorado Well Service. Rig #99. Cabot 900 with 112 foot derrick. Substructure 14.3 feet above ground level. Stabilization equipment on location. Water line laid from RRGE-1.
April 8, 1977	Spudded. Drilling 15 inch hole from 44 feet to 419 feet Kelly Bushing* (375 foot hole) in 10 hours. Center punch (4-1/2 hours) with 26 inch hole opener to start hole. Drilling with 10 6-1/2 inch x 2-1/4 inch drill collars. Collars (8 inch) from Nevada Test Site (NTS) not arrived. Drilling with pump #1 7-3/4 inch x 16 inch Idico 700 MM with 6 inch liners at 53 Strokes Per Minute (SPM). Pump #2 is a 7 inch x 14 inch Gardner Denver. Mud: weight 8.3 vis. 41. Bit #1, Sec. 15 inch @ 44 feet out, 419 feet Kelly Bushing drilled 375 feet in 10 hours.
April 9, 1977	Open hole to 26 inches from 44 feet to 190 feet. Drill collars 1 monel, 8 steel 7-3/4 inch x 3 inches. Bit 26 inches Hole Opener (HO).
April 10, 1977	Open hole to 26 inches to 410 feet, 8 hours. Circulate 2-1/2 hours, 2-1/2 hours trip lay down tools and hole opener 11 hours run in 20 inch casing with Parrish Oil tool. Had to speed and wash from 70 feet to bottom. Probable dogleg at 70 feet. Mud: weight 9.3.
April 11, 1977	Ran casing (2-1/2 hours). Total 10 joints, 20 inch H 40 94# casing, welder tacked each joint. Circulate 45 minutes to bottom 407 feet GL. 1/2 hour rig up. Halliburton start pump @ 4:05 A.M. dropped 60 bbl water ahead of thin mix lead slurry CIP @ 5:20 A.M. Slurry mix: 630 sks Pozmix, 35% silica flour, 2% calcium chloride. 60 bbl water ahead, displaced with 133 bbl gel mud. Clean shaker and equipment (10 hours) while W.O.C. 6 hours installing wellhead equipment. Mud: weight 9.3 vis. 43, vis. while circulating 32.

*All depth Kelly Bushing (KB) 14.3 feet above ground level unless specified.

DAILY DRILLING REPORTS

April 12, 1977

WOC (8 hours) while installing Bradenhead and 20 inch expansion spool, 20 inch single gate BOP and flow nipple. Nipple up (3 hours) for 1/2 hour pressure test. Held 300 psi for 15 minutes. Make up tools and trip in hole (1-1/2 hours), 3 hours drilling cement, shoe and float collar with bit #2 - 12-1/4 inches from 358 feet to 431 feet KB. Three hours drilling from 431 feet - 526 feet, 2-1/2 hour mix, circulate and condition mud. Two hour trip plugged bit. One hour deviation survey at 526 feet - 0^{o} 8 inches. Mud: weight 8.8 vis. 38.

April 13, 1977

Drilling 12-1/4 inch hole from 526 to 1456 feet (footage 930 feet)

Bit #2 Smith 2VJ. In 421 feet out 1097 feet drilled 676 feet, 14 hours.

Mud: weight 9.9 vis. 36.

April 14, 1977

Drilled 12-1/4 inches from 1456 feet to 1908 feet in 9-3/4 hours. Making up Joides corebarrel system.

Bit #3 Smith F2. In at 1097 feet, out at 1908 feet-drilled 801 feet in 18-1/4 hours. 1/4" OG. Mud: weight 9.3 vis. 36.

April 15, 1977

Two hour trip in with corebarrel. Stuck tool at stabilizer at 1450 feet. Bit depth 1488 feet, 14 hours work pipe. Spot with 1,000 gallon diesel at 1:30 P.M. Eight hours rig up Dialog, set off 2 string shots at 1448 feet. Back off corebarrel and stabilizer. Trip out. Go in hole with Bowen 8 inch jars and bumper sub. Screw into fish. Set off jars one time. Start out with fish 12 inch Stabilizer at 34.56 feet on top of corebarrel with 4 - 8 inch drill collars.

April 16, 1977

Four hour trip out with fish recovered everything. Eight hours Dresser Atlas logging hole. Mud gelled due to BHT 198^{o}F and standing in hole. Trip in hole (4-1/2 hours), circulate and condition hole. Dresser run logs (7-1/2 hours). Gamma density, Neutron density, Sonic, and Dual induction.

April 17, 1977

One hour Dresser Atlas logging. Five hour pick up corebarrel, 11 inch stabilizer, bumper sub and trip in hole. Two hour repair connection on swivel. Core (1-1/2 hour) 15 feet. Two hour circulate and condition hole. Trip out with core (3-1/2 hours) and lay down corebarrel. Recovered 3.5 feet core. USGS ran Temperature and Televiewer logs (13-1/2 hours). Core #1 Smith Joides in 1908 feet, out 1923 feet, drilled 15 feet in 1-1/2 hours.

DAILY DRILLING REPORTS

April 18, 1977

Three hours opening 12-1/4 inch hole with 17-1/2 inch hole opener. Drilled out cement from 358 feet to 419 feet condition and control mud contaminated with cement. Opened hole from 419 feet to 1310 feet.

April 19, 1977

Opened hole 17-1/2 hours from 1310 feet to 1923 feet, 4 hours circulate and condition hole.

Bit 17-1/2 inch Grant Hole Opener in 419 feet, out 1923 feet reamed 1504 feet in 36-1/2 hours. T5 B3 OG-1/4. Mud: weight 9.5 vis. 52.

April 20, 1977

Six hours USG attempted caliper log - no good. Twelve hours rig-up Lamb "Jam" system and ran 49 joints 13-3/8 inch K55 54.5# casing, guide shoe, float collar and DV tool - total 1927.95 feet. Set casing at 1901 feet G.L. DV tool @ 1397 feet. Four hours circulate. Stage cement with 60 bbl water ahead, 368 sacks poz mix, 35% silica flour and .03% Hallad 9. CIP at 10:10 P.M. Two hours circulate through ports and DV tool. Circulate excess cement to surface and continued to circulate with gel while W.O.C. 2 hours.

April 21, 1977

Six hours W.O.C. between stages. Two hour cement second stage through DV tool at 1397 feet to surface with 1013 sks Poz mix with 35% silica flour CIP @ 8:00 P.M. W.O.C. (12 hours) cut section out of adapter spool and set pack off slips on 13-3/8 inch casing. Four hour nipple up BOP equipment.

April 22, 1977

Nipple up BOP (12-1/4 hours). Installed expansion spool, master gate, adapter spool, double gate Schaffer BOP, Grant rotating head and flow line 1/2 hour test casing at 300 psi for 30 minutes with master gate valve closed. OK. One hour level derrick. Drilling DV tool (4-1/2 hours) at 1411 feet KB, float collar at 1875 feet and cement shoe at 1915 feet KB. Pressure test after drilling DV tool with Hydril closed at 300 psi for 15 minutes. Held OK. Drilling with water to 2025 feet.

April 23, 1977

Drilled 12-1/4 inches from 2025 to 2124 feet. Bit #4 Smith 2VJ in 1408 feet, out 2124 feet, drilled 202 feet in 11-1/4 hours. T7-B6 OG 1/8, 15-1/2 hour trip in with corebarrel with 9-7/8 inch core bit. Hit obstruction at 1901 feet, worked bit through rotating no drag on pull back. Worked through several times no improvement. Trip out (corebit still in good condition). Run in hole with Bit #5 Smith V2J, worked through tight sport at 1901

April 23, 1977 (Continued)

feet. Rotate to go through, no drag pulling back. No improvement. Pipe torqued up and backed off. Trip out to check. Backed off 15 stands (30 joints) down. Trip in and screw into tool. Bit lodged at 1901 feet. Trip out with Bit #5. Bit #5 Smith V2J 12-1/4 inch T6 B4 NG drilled 0 feet. Trip in with Bit #6 Smith V2J. Hit junk at 1901 feet. Attempt to work through it - No go.

April 24, 1977

Two hour trip out with Bit #6 Smith V2J 12-1/4 inch T5 B1 NG. Wait on milling tools (8-1/2 hours). Pick up flat bottom mill and trip in hole (3-1/2 hours). Hit junk at 1901 feet. Five hours mill 1901 feet to 1909 feet. Worked back and forth. Kept hanging up at 1901 feet, 3-1/2 hours trip out. Pick up 12-1/4 inch tapered mill and 12-1/4 inch stabilizer. Trip in. Hit junk at 1901 feet. Drill and work 12-1/4 inch tapered mill from 1901 feet to 1946 feet until mill would go without rotating (1-1/2 hours). Well flowing.

April 25, 1977

Trip out with 12-1/4" tapered mill and trip in with flat bottomed mill, junk sub and stabilizer (5-1/2 hours). One hour repair electrical system. Six hour milled from 1901 feet to 1909 feet. Trip out (3-1/2 hours). Lay down tools and rig to run electric log (EG&G). Two hours logged. Run in hole with 12-1/4 inch tapered mill and stabilizer. Hit junk at 1901 feet. Worked through to fill at 2065 feet (3-1/2 hours). Wash out fill to 2124 feet and circulate bottom. Start trip out (1/2 hour). Call out Petrolog to run collar log, cement bond and caliper log to diagnose situation.

April 26, 1977

Two hour trip out with 12-1/4 inch tapered mill. Eight hour run logs with Petrolog. Run caliper, collar locater and cement bond logs. Determine bottom 2 joints 13-3/8 inch casing parted and fell down hole. Male end looking up. Top of fish at 1901 feet. Bottom of cemented casing at 1835 feet. Collar looking down. Six hours run temperature log with EG&G logging unit. Temperature at 236.5^{o}F at top of parted casing at 1901 feet. Well flashing. Two hours install Hughes bit guide and trip in hole to 1901 feet. Work bit through top of fish. Trip took 2124 feet. No fill - very little junk. Drilled from 2124 feet to 2235 feet with Bit #7 Smith SVJ.

DAILY DRILLING REPORTS

April 27, 1977	Drilled from 2235 feet to 2445 feet in 9 hours, 4 hours wait on water. Lost all circulation at 2445 feet. This came back about 50%. Trip out, pick up core barrel into 1901 feet. Could not tag casing at 1901 feet. Trip out and pick up bit #8. Run in hole to 1901 feet and attempt to work through 13-3/8 inch casing - no go - keep falling off side of 13-3/8 inch casing. Bit #7 Smith SVJ in 2124 feet, out 2445 feet drilled 32 feet in 8-1/4 hours. T7 B6 OG 1/2 inch.
April 28, 1977	Trip out with Bit #8 (2-1/2 hours). Could not get inside 13-3/8 inch casing at 1901 feet. Pick up bit #8, 12-1/4 inch stabilizer, 2 drill collars, stabilizer, and 6 drill collars and trip in hole (2-1/2 hours). Attempt to work through casing at 1901 feet - no go (1-1/2 hour) - 1-1/2 hour trip out. Well flashing 2-1/2 hours pump cool water down hole. Two hour pick up 12-1/4 inch tapered mill and trip in hole. Two hour attempt to work through casing at 1901 feet - no go. Trip out (1-1/2 hour). Waiting on spear for 13-3/8 inch casing.
April 29, 1977	Wait on 13-3/8 inch casing spear (2-1/2 hours). Make up tools (1-1/2 hour). Start in hole. Slips too large. Break down spear, wait on smaller slips (7-1/2 hours). One hour dress spear. 1-1/2 hours trip in hole with bent 3-1/2 inch drill pipe stinger, 13'3/16 inch spear, 2 drill collars, jars, and 6 drill collars. Two hours work on spear in 13-3/8 inch casing at 1901 feet. Could not set spear, 1-1/2 hours trip out. One spring on setting device broken off. Replace spring (2-1/2 hours). Trip in hole (1-1/2 hours). 2-1/2 hours work spear in 13-3/8" casing working pipe and set off jars. Could not move fish (80 feet of 13-3/8 inch casing). One half hour start out of hole.
April 30, 1977	Trip out with 13-3/16 inch casing spear, 2-1/2 hour pick up bit #8 Smith SVJ with jars run into hole to 1901 feet. Work through 13-3/8 casing and go to 2390 feet. Clean fill from 2390 feet to 2445 feet (3/4 hour). Drilled from 2445 feet to 2834 feet (6-1/4 hours). Eight hour try to flow well for maximum temperature build up. No flow. Run temperature survey 180° maximum at 1700 feet.

DAILY DRILLING REPORTS

May 1, 1977

Trip out with bit #8 (2-1/2 hours). Pick up corebarrel, shock sub, collars and trip in hole (3-1/2 hours). Work through 13-3/8 inch casing at 1901 feet. Go to 2806 feet. One half hour clean out fill from 2806 feet to 2834 feet, 2-1/2 hours - core 20 feet. Trip out and empty core barrel (2-1/2 hours). Recover 13 feet. Three hour pick up bit #9. Trip in to 1901 feet. Attempt to work bit through - no go. Trip out (3-1/2 hours). Trip in with shock sub on bottom of collars. Attempt to work through at 1901 feet - no go (1-1/2 hours). Trip out (2-1/2 hours).

Bit #8 Smith SVJ in 2445, out 2834 drilled 389 feet in 8-3/4 hours. T6 B2 OG 1/8.

May 2, 1977

Pick up tapered 12-1/4 inch mill, float sub and bent joint 4-1/2 inch drill pipe (2-1/2 hours). Trip to 1901 feet. Two hours attempt to work through 13-3/8" casing. Got through with Kelly on but had to pull back for connection and could not get back in. Two hours trip out. Nine hours repaired geothermal logging unit. Three hours run temperature log. Maximum temperature 238°. Six hours pressure reading every 1/2 hour with well closed in. Closed in 35 psi dropped to 32 psi. Plan to do injection testing, temperature logs. Will quit hole at this depth 2854 feet T.D. KB (9-7/8 inch hole from 2834 feet to 2854 feet KB).

May 3, 1977

Five hour step injection test using both rig pumps. Injection test: WHP reached 50 psi at 30 spm (189 gpm) and reached maximum of 78 psi at 120 spm (534 gpm). Pick up four joints 9-5/8 inch casing with modified shoe and run to 1901 feet (2-1/2 hours). Worked 9-5/8" casing through 13-3/8 inch casing and go to 1952 (1-1/4 hours). Eight hours repair wireline and tool on logging unit. Run temperature log inside pipe (6-1/2 hours). Maximum temperature 252°F at 2700 feet.

May 4, 1977

Eight hours injection test and cool down well. Pumped 40 spm (280 gpm) 6 inch liners Duplex (7 gallon per stroke 100% efficiency). Started at 1:00 A.M. every 30 minutes thereafter. 46#, 48#, 41#, 46#, 62#, 65#, 65#, 70#, 60# shut-in @ 6-8# 7:00 A.M. 7#. Two hours trip out with drill pipe and 4 joints 9-5/8 inch casing with modified shoe. Casing (9-5/8 inch) run in parted casing to verify that well could be completed later with 9-5/8 inch casing for production well.

May 4, 1977
(Continued)

Three hours break down corebarrel. Five hours lay down drill pipe and 8 - 8 inch drill collars. Closed master gate at 9:00 P.M. Rig down.